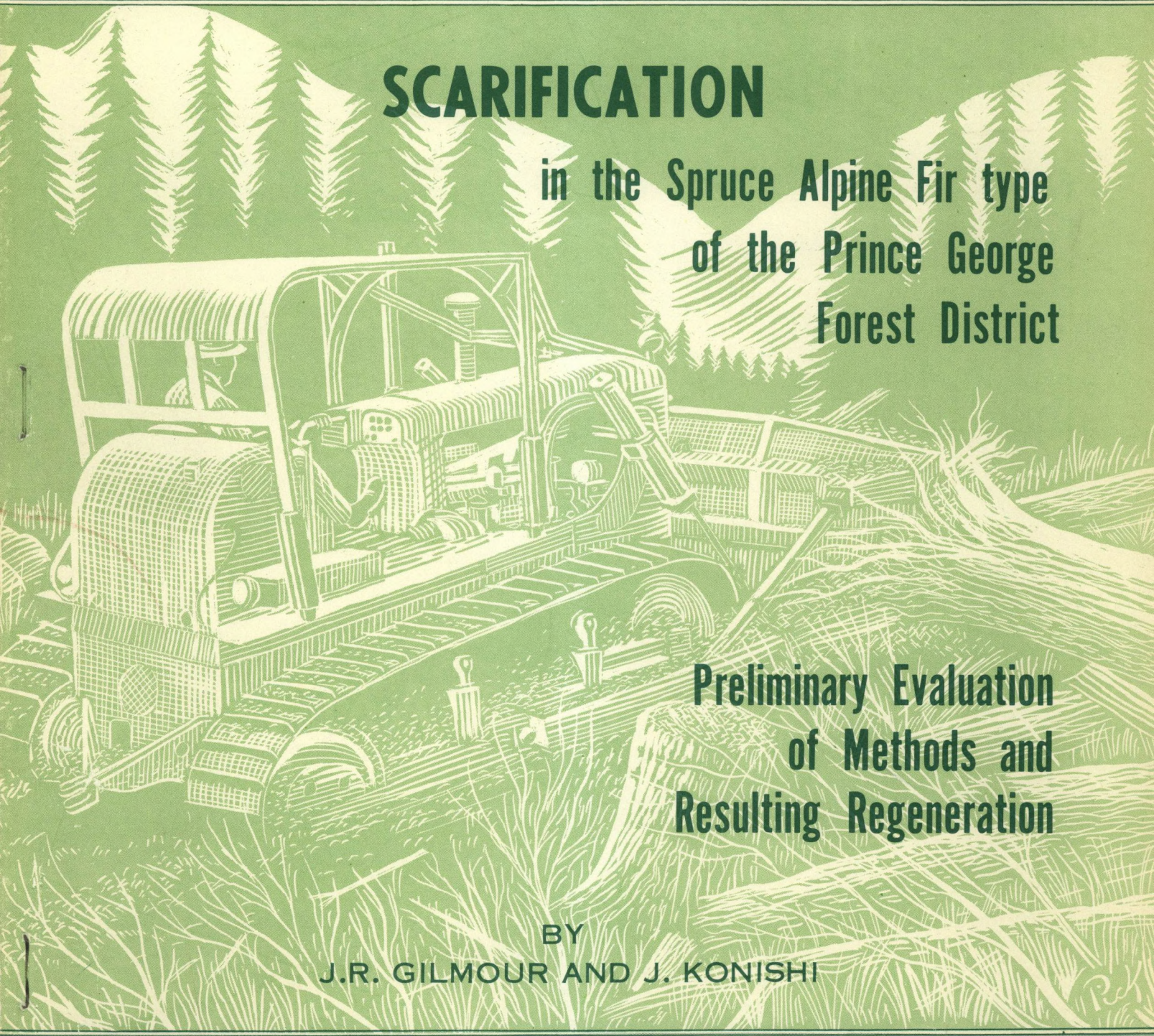
N COATES

FOREST MANAGEMENT NOTES

BRITISH COLUMBIA FOREST SERVICE

No. 4 FOREST MANAGEMENT DIVISION 1965



SCARIFICATION

in the Spruce Alpine Fir type of the Prince George Forest District

Preliminary Evaluation of Methods and Resulting Regeneration

BY

J.R. GILMOUR AND J. KONISHI

DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
VICTORIA, B.C.

SCARIFICATION

IN THE

SPRUCE - ALPINE FIR TYPE OF THE PRINCE GEORGE FOREST DISTRICT

PRELIMINARY EVALUATION OF METHODS AND RESULTING REGENERATION

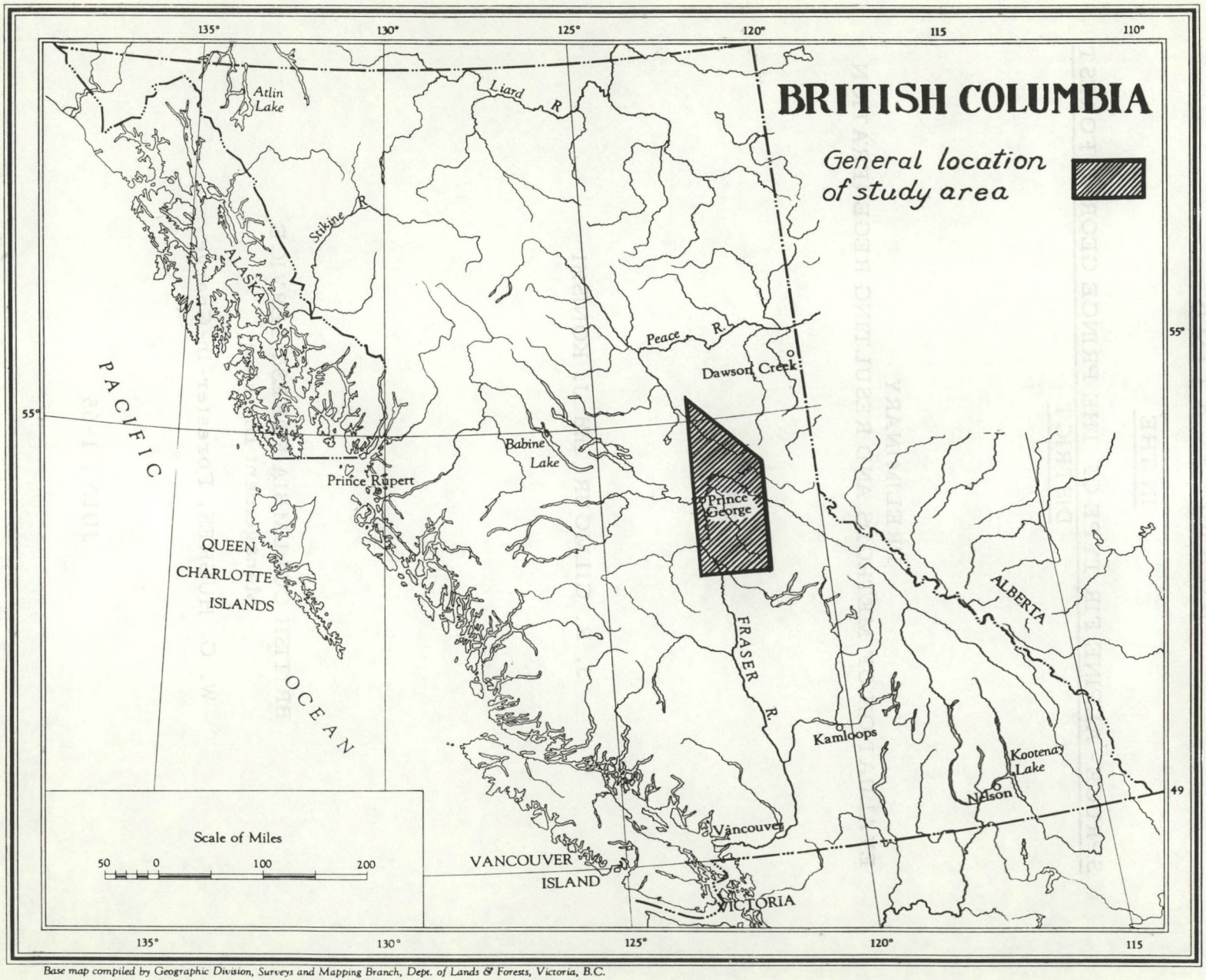
by

J. R. GILMOUR and J. KONISHI

BRITISH COLUMBIA FOREST SERVICE
Management Division

W. G. HUGHES, Forester-in-Charge

JULY, 1965



Base map compiled by Geographic Division, Surveys and Mapping Branch, Dept. of Lands & Forests, Victoria, B.C.

TABLE of CONTENTS

LIST OF ILLUSTRATIONS AND DIAGRAMS

LIST OF FIGURES

SCARIFICATION
IN THE
SPRUCE - ALPINE FIR TYPE OF THE PRINCE GEORGE FOREST DISTRICT

PRELIMINARY
EVALUATION OF METHODS AND RESULTING REGENERATION

****

PREFACE

The forests of the study area have been classified by Rowe[9] as lying within the Montane Transition Section of the Montane Forest Region, and within the Interior Section of the Sub-Alpine Region to the north and at higher elevations. Both are predominantly spruce-alpine fir types.

Arlidge[2] further sub-divides the Montane Transition Section into five major spruce-alpine fir site types based on an ecological classification. Listed in order of decreasing productivity, the site types are: Oplopanax (O), Disporum (D), Aralia-Dryopteris (A-D), Cornus-moss (C-M) and Equisetum-Sphagnum (E-S).

All site types have a humus layer, and this limits prompt natural regeneration of spruce. However, the alpine fir component has little difficulty in regenerating on duff and moss layers (Place[7]). The quantity and quality of the alpine fir in the understory of mature stands varies between areas - even between those of similar site type (Arlidge[2]). Tree-length logging with crawler tractors can cause extensive damage to this understory.

Recent studies in unlogged stands and in those logged prior to 1954 indicate a high incidence of decay in alpine fir understories (Smith[10]). It would appear that there is a high incidence of decay on (O) Devil's Club sites, with a lower incidence on (C-M) sites. However, there is a difference of opinion over the crop potential of alpine fir understory, and further investigation is needed. Even so, it can be surmized that, in many instances, the alpine fir understory will not form a desirable crop.

In early attempts to overcome the lack of post-logging regeneration, stands were harvested either on a high-diameter limit or marked

under single tree selection or the seed block method, with up to 50 per cent of the merchantable volume being reserved. In 1963, Glew[5] evaluated the cutting practices in the white spruce-alpine fir type of the Northern Interior. He reported that regeneration was more successful with alternate strip-cutting than when selectively logged areas were used. This was especially true when strip-cutting was followed by scarification.

Recent experience indicates that considerable volume losses can be expected because of windthrow and insect infestations. The increase in windthrow is related in part to the "opening up" of over-mature virgin stands. This exposes cutting margins to strong winds which often occur when the ground is saturated.

Widely-scattered attacks of spruce bark beetle (Dendroctonus obesus Mann.) have occurred both in virgin stands and in the cutovers. The outbreak first was noted in 1962 when Cottrell et al[3] suggested that the increase in unsalvaged windthrow and favourable weather had combined to precipitate the population buildup.

In an effort to reduce volume loss, the present practice is to remove the entire stand following pre- and post-scarification. Where scarification is feasible, a system of cut-and-leave strips, or patches, is established. The temporary leave strips are pre-scarified; then removed by winter logging when regenerated. Ideally, the post-scarification of the initial-cut strips and the pre-scarification of the temporary reserves are kept current with the logging of the cut areas. This system has a "built-in" flexibility which allows complete removal when windthrow and insect damage appear. Where complete removal is necessary, site preparation must be followed by artificial seeding or planting.

The periodicity of seed crops and the regional variation of these crops affect the regeneration following scarification. Scarified seed beds generally remain receptive for up to three years in the Prince George Area (Arlidge[2]); while in Alberta this may be extended to five years (Lees[6]). This time limit to receptivity of scarified seed beds adds to the overall problem of administration.

Scarification probably will be retained as an effective means of site preparation preceding either natural or artificial regeneration. As this treatment generally is restricted to an estimated 30 per cent or less of the logged acreage, it therefore does not appear to limit the use of other treatments. For the present, scarification is regarded as the best operational means of obtaining regeneration.

INTRODUCTION

In the summer of 1956, scarification trials were initiated in an endeavour to secure spruce regeneration. Subsequent stocking surveys revealed encouraging results.

The annual scarification programme has increased from 243 acres in 1956 to more than 10,000 acres in 1964. To date, approximately 35,700 acres have been scarified.

This report describes scarification procedures and methods, and equipment used, accompanied by a summary of costs. The regeneration following scarification is evaluated, based on a mil-acre survey carried out between 1960 and 1964.

The results of scarification are based on a sampling of 6,549 acres. Although approximately 35,700 acres have been scarified so far, comparable survey methods were not used prior to 1959. Sales after 1962 have not been included as there has not been sufficient time to permit complete assessment.

Direct costs of scarification, based on transportation and rental of machines, are expressed as average per-acre costs for several types of equipment.

SCARIFICATION PROCEDURES

Pre-Examination

Cut-over areas are examined to determine the feasibility of and priority required for scarification. Two broad criteria are considered: first - wherever possible, costs should not exceed $15.00 per acre; second - scarification must create a favourable seed bed of 60-65 per cent of the area (Decie and Fraser[4]).

General rules for determining the suitability of pre-scarification (before logging) and post-scarification (after logging) are outlined below:

1. Crawler tractors generally are effective on grades under 30 per cent and on sites lacking excessive rock outcropping or large surface boulders (3'-4' diameter).

2. Scarification is confined to (O), (D), (A-D) and (C-M) site types, which generally are well-drained. The (E-S) types - margins of swamps, flood plains and other areas of restricted drainage - are avoided.

3. Scarification is considered only where there are less than 160-11"+* stems per acre. This figure will decrease as physical obstacles such as stagnated understory, windthrow and/or slash increase. The difficulty of scarification is reduced if stumps or windthrow are rotten.

4. Scarification generally is restricted to high sites (S.I. 80 or better). High elevation stands of short timber with a low volume of spruce and/or high density of decadent alpine fir are avoided.

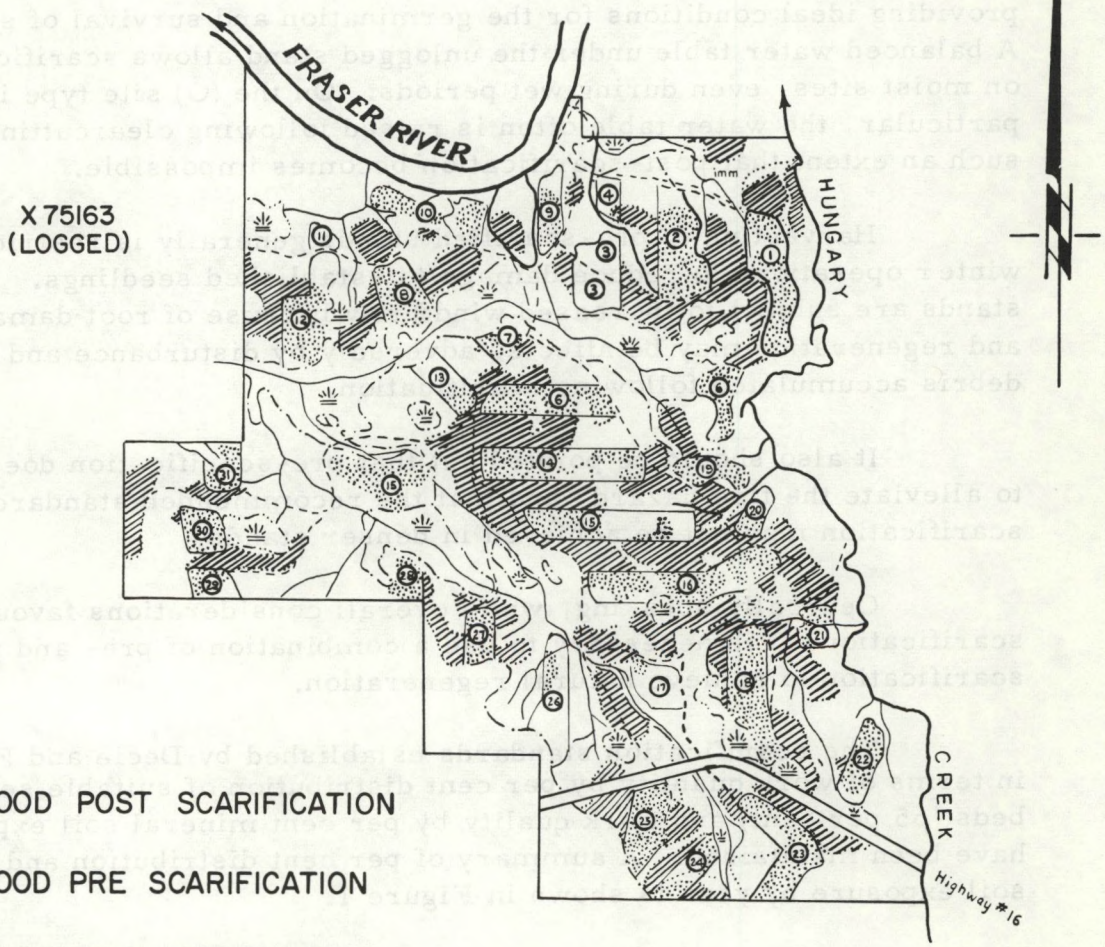
Maps showing good, poor and no scarification possibilities are used to plan the programme. Later, the layout of alternate strips or seed blocks allows a refinement into good or poor pre- or post-scarification, with pre-scarification practised on the reserved area (Diagram 5 - p. 5).

Methods and Standards

Scarification is controlled by laying out a systematic pattern suitable for the machine and individual ground conditions. As a rule, the periphery of an area is outlined and scarified. Following this, the

* Diameter at breast height.

MAP OF X82762
SITUATED: S. SHORE FRASER RIVER
LAND DISTRICT: CARIBOO
TOTAL AREA: 2635 ACRES
ATLAS REF: R93H N.W. (E – 4)
REGION: 59 COMPT.: 65
SCALE: 40 CHAINS = 1 INCH.



GOOD POST SCARIFICATION

GOOD PRE SCARIFICATION

POOR POST SCARIFICATION

POOR PRE SCARIFICATION

TEMPORARY RESERVE STRIPS

tractor scarifies in a zig-zag pattern across the narrow axis of the strip or block. Return passes are kept approximately one blade-width apart. On steeper slopes (i.e. 20-30 per cent), it often is advantageous to work continually in decreasing circles, parallel to contour, until the centre of the area is reached.

Similar methods are employed in pre-scarification and in post-scarification. Post-scarification, however, has the advantage of providing a maximum amount of scarifiable ground with minimum damage to standing trees. In addition, post-scarification may reduce the fire hazard by breaking the continuity of the slash with patches of mineral soil.

On the other hand, pre-scarification has the advantage of providing ideal conditions for the germination and survival of spruce. A balanced water table under the unlogged stand allows scarification on moist sites, even during wet periods. On the (O) site type in particular, the water table often is raised following clearcutting to such an extent that post-scarification becomes impossible.

Harvesting of pre-scarified stands generally is restricted to winter operations to reduce damage to established seedlings. These stands are subject to increased windthrow because of root damage, and regeneration may be affected adversely by disturbance and logging debris accumulated following scarification.

It also should be pointed out that pre-scarification does nothing to alleviate the fire hazard, and that the recommended standard of scarification may not be achieved in denser stands.

Generally speaking, while overall considerations favour post-scarification, it is necessary to use a combination of pre- and post-scarification to achieve natural regeneration.

The scarification standards established by Decie and Fraser[4] in terms of work quantity by per cent distribution of suitable seed beds (65 per cent) and work quality by per cent mineral soil exposure have been maintained. A summary of per cent distribution and mineral soil exposure by year is shown in Figure 1.

FIGURE I

SUMMARY OF SEEDBED DISTRIBUTION

(Note - Includes pre- and post-scarification)

Year	Number of Sales Sampled	Distribution of Suitable Seed Bed[a] Per Cent		Number of Sales Sampled	Mineral Soil Exposure	
		Average	Range		Average	Range
1959	18	66	47-79	18	34	18-44
1960	8	65	53-81	4	33	27-41
1961	7	67	59-76	7	34	30-38
1962	17	61	58-69	17	33	24-50
1963	16	62	52-73	15	33	17-38
1964	20	64	57-70	*	*	*

(a) Mineral soil and/or rotted wood.

* Mineral soil exposure not surveyed.

During the period 1959-64, an average of 64 per cent distribution of suitable quadrats was achieved. In most (O) site types, the required standard can be obtained readily by pre-scarification, providing the ground is not excessively wet. The open stocking allows machines easy access and manoevrability. However, in (C-M) site types the density of stems occasionally can prohibit pre-scarification.

Factors Influencing Cost of Scarification

The scarification costs on a per acre basis are influenced by the amount of precipitation, as shown in Figure 2.

FIGURE 2

A COMPARISON OF THE ANNUAL SUMMER PRECIPITATION WITH AVERAGE SCARIFICATION COSTS, 1959-1964

Year	1959	1960	1961	1962	1963	1964
Cost per acre[(a)]	$15.80	$15.10	$8.90	$11.50	$10.32	$11.40
Precipitation[(b)] (June-Sept. incl.)	11.60"	10.62"	7.26"	9.75"	10.67"	18.55"
Acreage Treated	1,160	816	1,175	2,104	4,233	7,189

(a) Direct cost includes hire by the hour and per acre contracts, pre- and post-scarification, use of machines of varied size and make, and all field conditions.

(b) Monthly Meteorological Summary, Prince George Airport, B. C., Meteorological Branch, Federal Department of Transport.

A wide range of costs can be expected in any one season. For example, the 1964 range was from $6.50 to $17.00 per acre. Scarification costs per acre for 1959 and 1960 were considerably higher than those for subsequent years; probably due to poor supervision, inadequate knowledge of methods and machines, and lack of operator experience.

The amount of summer precipitation can have a decided effect on scarification costs. The 1961 scarification cost of $8.90 per acre was related to dry conditions experienced during the summer months, although the experience gained in 1959 and 1960 also is partially responsible. However, despite the fact that precipitation during the

1964 season was abnormally high (18.55"), the cost of scarification did not rise significantly. This is attributed to the fact that pre- and post-scarification were timed to provide for the lower average costs under the optimum working conditions.

Rieche[8] in dealing with factors affecting cost of post-scarification, concluded there was a direct relationship between the physical factors of the individual area, the machine size and the cost of scarification. Cost tables were calculated on the basis of different machine sizes, degrees of soil moisture, slash conditions and slope conditions. The advent of pre-scarification adds yet another variable to those already affecting cost.

While this report will not attempt to correlate these variables, the following general observations influencing cost are made:

1. Glacial till soils offer the best overall opportunity for scarification.

2. The (O) site types are more expensive to scarify than (C-M) site types. Glew[5] found the cost to be three times greater on (O) than on (C-M) site types.

3. Pre-scarification often is effective during wet working conditions and may be carried out where post-scarification of the logged area is impossible or the cost prohibitive.

4. Adequate pre-examination of areas proposed for scarification is required. Cost is lowered by organization of pre- and post-scarification to reduce layout and supervision time.

5. Once machines have been employed, adequate supervision and timing of the machines on the job lowers the cost per acre and provides a high standard of performance.

6. At least two machines should be used in each area to avoid costly delays due to a machine "bogging down".

7. Machine maintenance, horsepower, operator skill and instruction all have a significant effect on cost. A schedule* of payment based on horsepower rating, model and serial number is required to obtain maximum efficiency and to set work standards.

8. Machines with less than 80 D.B.H.P.+ are not as efficient as those with more than 100 D.B.H.P. in spruce-alpine fir stands (Rieche[8]). Field observations indicate that a machine between

---

* Basis: Fire Suppression Equipment Rental Schedule, Forest Protection Division.

\+ Draw Bar Horsepower.

102 - 160 D. B. H. P., equipped with an angled hydraulic blade, winch and cab-guard, generally is most satisfactory. In three instances it was found that an ideal combination of horsepower, blade and rental rate was a caterpillar tractor ~~Model D-7, 17A~~, rated at 155 D. B. H. P., or its equivalent. The blade was narrowed from a width of 14 feet down to 10 feet and slightly angled, with extremities of the blade paralleling maximum track width. This modification improves the operator's visibility and the machine's manoeuvrability in both pre- and post-scarification between stumps and trees. As the "narrow" blade moves a smaller amount of slash and other debris than the standard blade there is a consequent increase in horsepower efficiency.

D-7, 17A - Equipped with Narrow Blade

Other special blades, notably the "V" type, have been used in scarification. One "V" type was contructed from the welded halves of a regular D-7 blade. The apex of the blade extended 36 inches from the base. However, the blade was unsatisfactory

in this form as slash would not clear, nor would the mold board expose mineral soil, except on flat surfaces. When lowered, the

Unsuccessful "V" Type Blade

blade created excessive drag. Extension of the nose of the mold board at the apex, inclusion of an upper deflector bar and raising of the mold board tail 4-6 inches above the apex level might provide favourable modification of the "V" blade.

REGENERATION ON SCARIFIED AREAS

Method of Survey

The list quadrat method described by Allen et al[1] is used in regeneration surveys with appropriate modifications.* A minimum of 200, one-mil acre plots is established on each scarified area. Plot lines are oriented across the major scarification axis. The number of plots, plot intervals and strip intervals are varied to provide the best systematic sample. Both mineral soil and undisturbed seed beds within the scarified area are checked for seedlings which have established themselves after scarification. Prior to 1962 only spruce regeneration was recorded, but all coniferous regeneration has been tallied in later surveys. Attempts are made to relate regeneration to broadly-defined strata - aspect, site, seedcrop, etc.

Results of Regeneration Survey

A summary of regeneration on 62 timber sales (6,549 acres), scarified by the Forest Service or by timber sale Licensees+, is shown in Diagram 6 (p. 13). The average stocking of all species was 49 per cent, with a range of from 4 to 94 per cent. The average stocking of spruce was 44 per cent. Accepting the B. C. Forest Service minimum of 31 per cent stocking by mil-acre quadrats as the criterion, 91 per cent (5,948 acres) of the scarified area has regenerated satisfactorily, while satisfactory restocking of spruce has been achieved on 85 per cent of the 6,549 acres studied.

Estimates of numbers of seedlings per acre and of species composition are illustrated in Diagrams 7A and 7B respectively (p. 14). The survey indicates an average of 4,833 seedlings per acre, with a range of from 10 to 21,461. Eighty-nine per cent of the area is stocked with spruce, 7 per cent with alpine fir and 4 per cent with a mixture of spruce, lodgepole pine and Douglas fir.

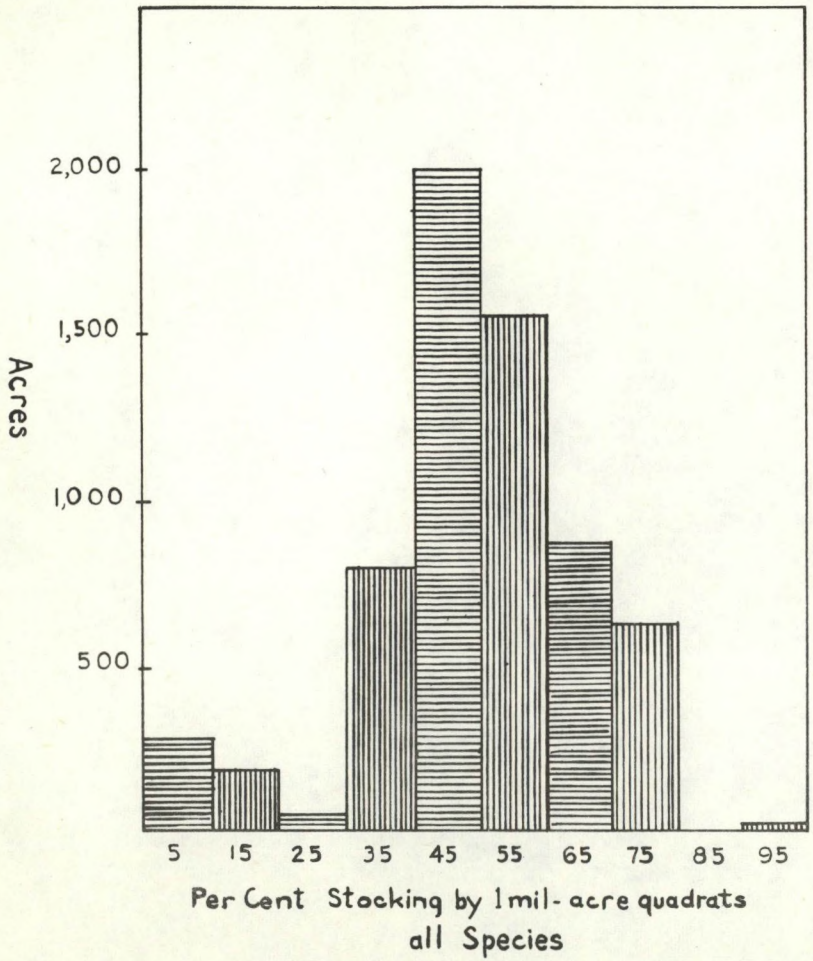
---

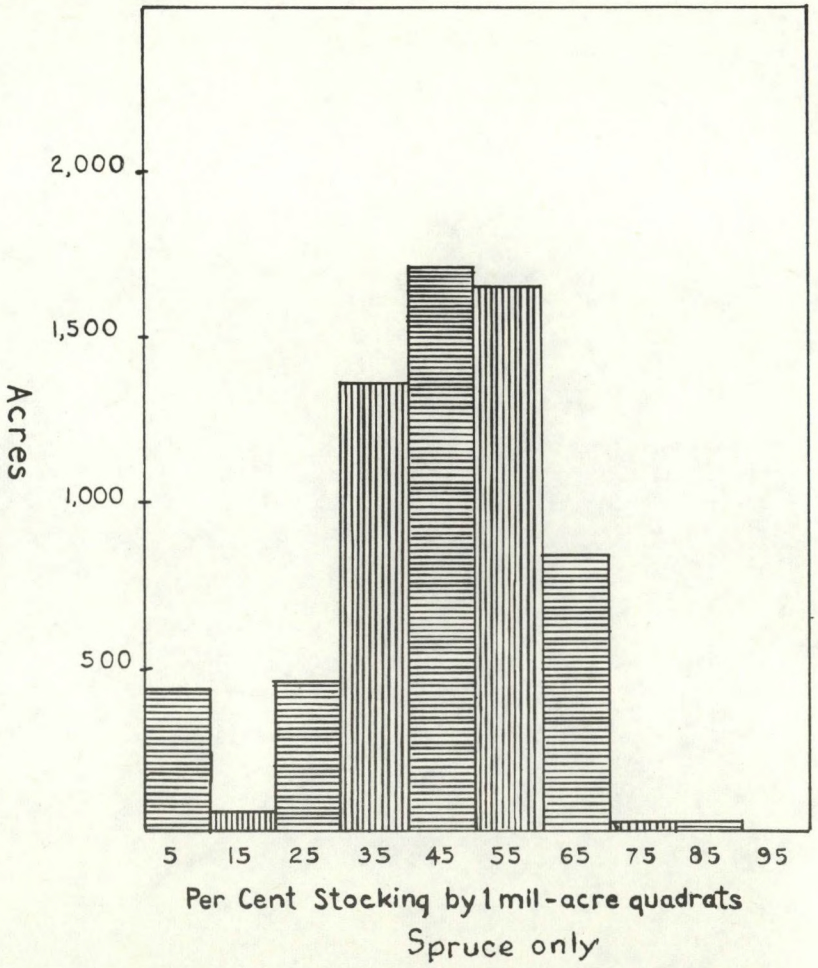
* All seedlings up to 10 are counted on each plot. Plots with more than 10 seedlings are tallied as "10 plus". All seedlings on every "10 plus" are counted.

+ Licensee scarification carried out by Licensee under contract clause.

(6)

Summary of Per Cent Stocking on 6549 acres scarified between 1956 1962 ☆
(Including only regeneration subsequent to scarification)



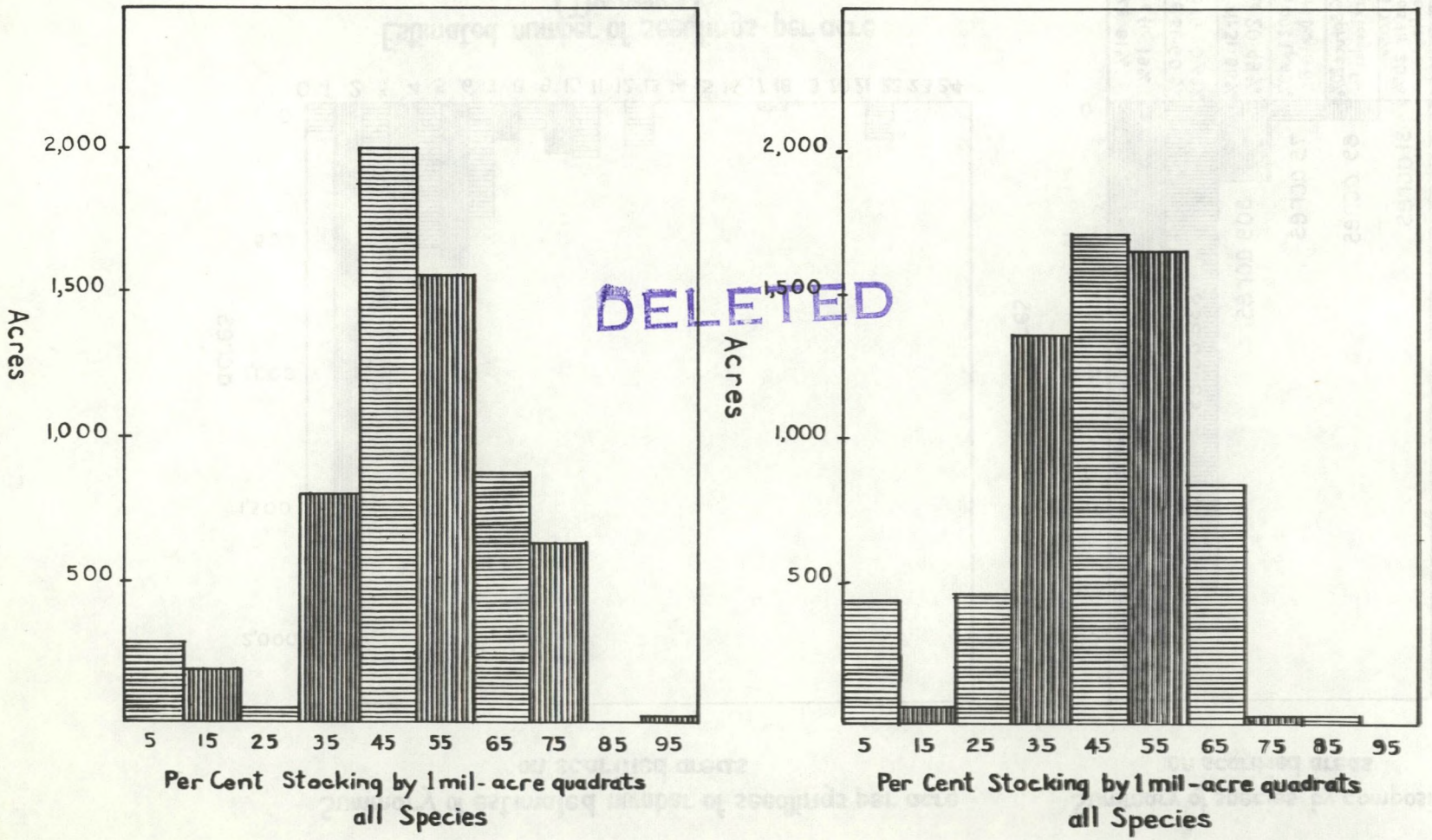


☆ (BASIS - 12,400 mil-acre quadrats)

Amendment to original page 13

(6)

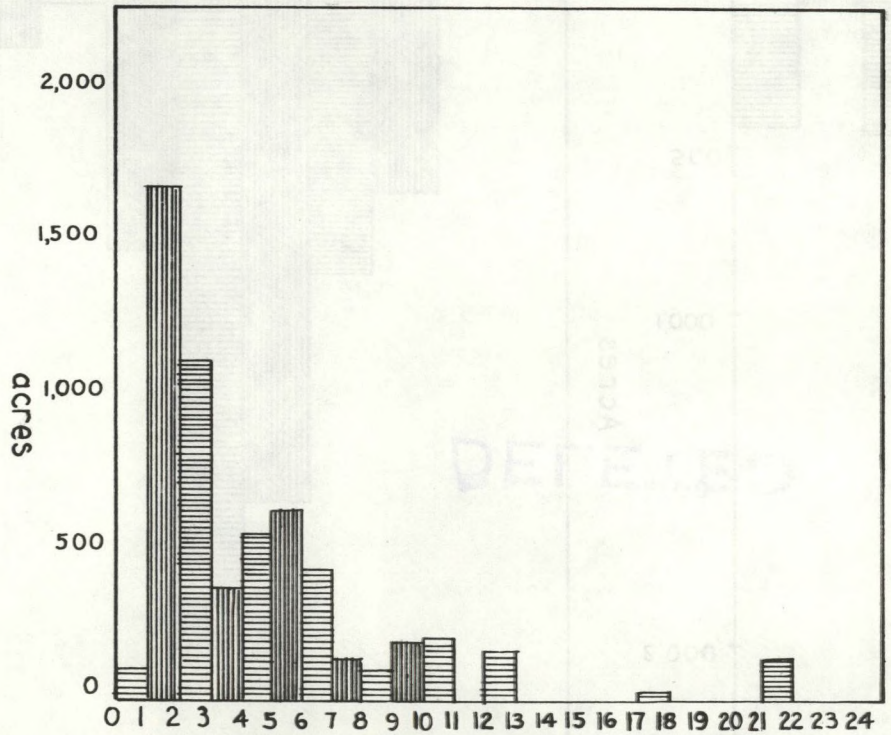
Summary of Per Cent Stocking on 6549 acres scarified between 1956 1962 ☆
(Including only regeneration subsequent to scarification)



☆ (BASIS - 12,400 mil-acre quadrats)

(7A)

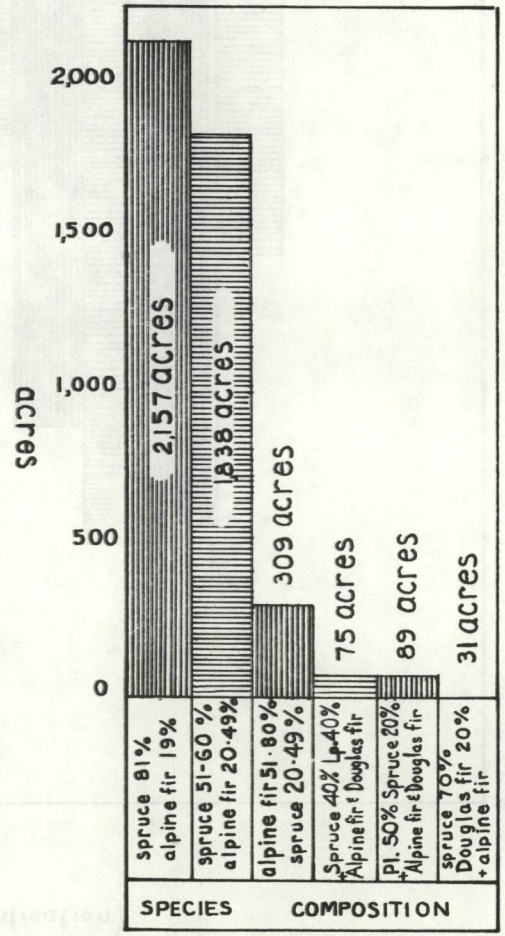
Summary of estimated number of seedlings per acre on scarified areas



Basis 58 timber sales per 5961 acres

(7B)

Summary of species by composition on scarified areas



Basis 40 Timber sales per 4499 Acres

Young[11] recommended that scarification be timed to coincide with good seed years* to ensure success. Most of the scarification so far has been done during good seed years. However, 12 areas (1,359 acres) were treated during poor seed years. Only two areas (179 acres), or less than 31 per cent, were not stocked. The average stocking in all species for areas treated during poor years was 43 per cent, compared to the 49 per cent obtained overall. This is attributed to subsequent good seed crops one or more years after scarification. A longer time lapse between scarification and seed crop would result in much lower stocking in most of the areas.

It is difficult to time all scarification with a seed year in the Prince George area because of lack of manpower and necessary equipment. Where scarification involves a timber sale Licensee, it is impossible to time treatment to coincide with a seed year since the governing factor is the life of the timber sale contract. A calculated risk must be accepted under these circumstances. Scarification should be avoided whenever possible in the years immediately following a "bumper" crop, as heavy crops normally are followed by only light cone production, if any at all.

Of the 62 timber sales examined, nine (601 acres) contained less than 31 per cent stocking. One of the nine was located on alluvial soil, while the others were located on (O) site types with a relatively high clay content. Due to high moisture retention in these soils and to their fertility, mortality through frost-heaving of germinates and rapid "brushing-in" of scarified beds decreased the chance of adequate stocking.

However, not all (O) site types remain unstocked. Although stocking generally is lower than on other site types, scarification during a good seed year has resulted in an increased percentage. In 1959, for example, stocking was over 31 per cent.

Scarification carried out on flat, poorly-drained (O) clay sites generally results in a dense cover of woods horsetail (Equisetum sylvaticum Linnaeus) within two years. Under these conditions the chance of seedlings establishing themselves more than two years after scarification is remote. Hence, pre-scarification appears to provide a better micro-habitat than post-scarification.

---

* Classification of cone crops by annual surveys - Form RN No. 19A.

When scarified, some poorly-drained clay soils tend to "bake" following exposure and therefore are not too receptive. However, margins left on either side of the tractor blade or track will support seedlings.

Inadequate regeneration also can be expected on "black muck" soils which are associated with alder swales and the (E-S) site type. Although sparse, advanced regeneration of spruce and/or alpine fir on "black muck" soils may provide a crop stand. As water is retained throughout the soil profile, scarification often transforms these areas into swamps and destroys most of the existing coniferous regeneration.

COMMENTS AND CONCLUSIONS

Methods and Costs

The average annual cost of scarification in the Prince George Forest District has varied between $9.00 and $12.00 per acre*. The lowest costs can be expected during seasons with little or no precipitation. Costs for individual scarification projects ranged between $6.50 and $17.00 per acre during 1964. However, maximum costs can exceed $17.00 per acre if scarification is not stopped during unfavourable weather or when adverse soil, slope or slash conditions are encountered.

In contrast to silts or clays, glacial tills and sandy soils can be treated during wetter periods such as June and early July, especially if pre-scarified. Post-scarification can be carried out more readily during drier periods. Scarification on south slopes should be done earlier than on north slopes.

The use of a well-maintained crawler tractor of from 102 to 160 D.B.H.P., equipped with a cut-down blade, is efficient for most pre- and post-scarification. Incidentally, the more powerful tractor is preferable. Once the machine has been leased, the operator should be given careful instruction and close supervision. It also is of considerable assistance if "scarification maps" are used to reduce travel time between areas selected for scarification.

Regeneration

Spruce-alpine fir cut-over areas can be restocked satisfactorily by scarification where the slope, soil and slash conditions do not limit the use of machines. Every effort should be made to carry out scarification during seed years to increase the opportunity for successful regeneration.

An average stocking of 49 per cent in all species has been achieved on 6,549 scarified acres which were sampled during this study. This stocking does not include advanced regeneration which complements the post-treatment regeneration.

---

* These figures do not include the cost of supervision.

Spruce Regeneration on Scarified Seed Beds

Alluvial soils on flood plains, "black muck" soils associated with alder swales, and (E-S) site types show poor regeneration results and are not recommended for scarifying. The (O) site type associated with poorly-drained clays should be either pre-scarified during a good seed year or planted.

Excessive soil moisture probably is the most significant factor inhibiting adequate regeneration on alluvial and "black muck" soils.

In conclusion, although scarification does contribute to successful regeneration in the spruce - alpine fir forests, other treatments such as seeding, planting, burning, etc., will be necessary to augment scarification in the Prince George Forest District. Seeding or planting in conjunction with scarification will be required when seed sources have been lost or when receptivity of the seed bed is likely to disappear before a good seed crop.

BIBLIOGRAPHY

1. ALLEN, George S., B. G. GRIFFITH and J. W. KER, 1951. A comparison of several regeneration survey methods in terms of cost and usefulness. University of British Columbia, Faculty of Forestry, Research Note No. 3, 6 pp.

2. ARLIDGE, J. W. C., and K. ILLINGWORTH 1960. Interim report on some forest site types in lodgepole pine and spruce-alpine fir stands. Department of Lands, Forests and Water Resources, B. C. Forest Service, Research Note No. 35, 44 pp.

3. COTTRELL, C. B., D. A. ROSS and E. V. MORRIS 1963. Spruce beetle report Prince George Forest District, Interim Report, Canada Department of Forestry, Forest Entomology and Pathology Laboratory, Victoria, B. C. Unpublished Report, 15 pp.

4. DECIE, T. P. and A. R. FRASER, 1960. Miscellaneous notes on scarification trials, Prince George Forest District, 1956-1959, Department of Lands, Forests and Water Resources, B. C. Forest Service, Victoria, B. C. Research Note No. 36, 22 pp.

5. GLEW, D. R. 1963. The results of stand treatment in the white spruce alpine fir type of the northern interior of British Columbia, Department of Lands, Forests and Water Resources, B. C. Forest Service, Forest Management Note No. 1. 27 pp.

6. LEES, J. C. 1963. Partial cuttings with scarification in Alberta spruce-aspen stands. Canada Department of Forestry, Forest Research Branch. Publication No. 1001. Queen's Printer, 17 pp.

7. PLACE, I. C. M. 1955. The influence of seedbed conditions on the regeneration of spruce and balsam fir. Canada Department of Northern Affairs and National Resources, Forestry Branch. Bulletin No. 117, Queen's Printer, 87 pp.

8. RIECHE, K. W. 1961. A preliminary study of the economic use of crawler tractor equipment for scarification. B. C. Forest Service Engineering Services Division. Unpublished Report, 29 pp.

9. ROWE, J. S. 1959. Forest regions of Canada. Canada Department of Northern Affairs and National Resources, Forest Branch. Bulletin No. 123. Queen's Printer, 71 pp.

10. SMITH, R. B. 1964. Preliminary report on decay in advanced balsam in the Prince George Forest District. Canada Department of Forestry, Forest Entomology and Pathology Laboratory, Victoria, B. C. Unpublished Report, 3 pp.

11. YOUNG, W. 1959. Progress to date on those timber sales containing a scarification clause. B. C. Forest Service, Prince George, B. C. Unpublished Report, 13 pp.
